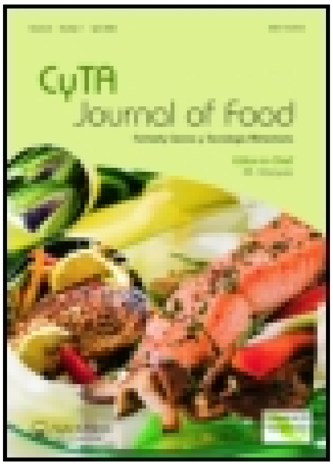

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Effect of dietary organic and inorganic selenium supplementation on chemical, mineral and fatty acid composition of ostrich meat

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SHORT COMMUNICATION

Effect of dietary organic and inorganic selenium supplementation on chemical, mineral and fatty acid composition of ostrich meat

Efecto del suplemento de selenio alimentario orgánico y no orgánico en la composición química, mineral y de ácidos grasos en la carne de avestruz

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This study evaluated the effect of dietary organic and inorganic selenium supplementation on chemical, mineral and fatty acid composition of ostrich meat. Forty ostriches were raised in two groups (OSe and IOSe, diets supplemented with an organic form and an inorganic form of selenium, respectively). The form of selenium had no influence on chemical composition of ostrich muscle. Although, there were no significant differences in total content of SFA, MUFA and PUFA, the content of LA and EPA was higher in the muscles of ostriches which were put on a diet supplemented with an organic form of selenium, what resulted in lower n-6/n-3 fatty acids ratio in OSe group (9.99) in comparison to IOSe group (11.70). The results of the study indicate that dietary organic selenium supplementation improves the quality of the ostrich meat as related to the health promoting properties (LA, EPA and selenium content) of meat.

Keywords: fatty acids; meat; ostrich; selenium

Este estudio evaluó los efectos del suplemento de selenio alimentario orgánico y no orgánico en la composición química, mineral y de ácidos grasos de la carne de avestruz. Se criaron cuarenta avestruces en dos grupos (OSe y IOSe, con dietas con suplemento de selenio en forma orgánica y no orgánica, respectivamente). La forma de selenio no tuvo ninguna influencia en la composición química del músculo de avestruz. Aunque, no hubo diferencias significativas en el contenido total de SFA, MUFA y PUFA, el contenido total de LA y EPA fue mayor en el músculo de los avestruces alimentados con dieta con suplemento de selenio orgánico, lo cual resultó en un menor valor de ácidos grasos n-6/n-3 en el grupo OSe (9,99) en comparación con el grupo IOSe (11,70). Los resultados de este estudio indican que el suplemento de selenio alimentario orgánico mejora la calidad de la carne de avestruz gracias a sus propiedades saludables (LA, EPA y contenido de selenio).

Palabras clave: ácidos grasos; carne; avestruz; selenio

Introduction

Ostrich meat as a good source of protein may enrich a rational diet. Today, the main European producers of ostrich meat are Belgium, France, Italy, Portugal and Spain. Meanwhile, production is developing apace in other countries, such as Poland and Croatia (Medina & Aguilar, 2014). However, the production is primarily in South Africa ranging from 300 to 350,000 birds raised for slaughter. In Europe, Germany consumes around 5000 tons of ostrich meat annually (Poławska, Cooper, Jóźwik, & Pomianowski, 2013). Increase in production is related to an increase in demand for ostrich meat. Higher interest in ostrich meat among consumers is associated with a growing awareness of healthy food as well as a wish to diversify the everyday diet. Ostrich meat is characterized by relatively high amounts of polyunsaturated fatty acids compared to chicken and beef (DalleZotte et al., 2013; Horbańczuk, Tomasik, & Cooper, 2008; Horbañczuk et al., 1998; Michalczuk, Łukasiewicz, Zdanowska-Sąsiadek, & Niemiec, 2014; Poławska et al., 2011, 2014; Poławska, Horbańczuk, et al., 2013; Sales & Horbańczuk, 1998) and is therefore more susceptible to oxidation processes. According to Grau, Guardiola, Grimpa, Barroeta, and Codony (2001) dietary supplementation with antioxidants including selenium can be effective to maintain lipid stability in meat. Selenium is a constituent of cellular and plasma glutathione peroxidase and is an essential enzyme in nutrient metabolism and cellular function (Perez et al., 2010). Moreover it is well known that selenium can be stored in the tissues and in periods of insufficient intake can be released by normal metabolic processes and used by the organism (Rayman, 2005).

In the feeding of farm animals selenium in the diet is available in inorganic as well as in organic form. Lyons, Papazyan, and Surai (2007) reported that until recently the supplemental form of selenium for farm animals has been inorganic, either selenite or selenate. Therefore, it would be worth undertaking research on the effectiveness of different forms of selenium in the ostrich diet in relation to the nutritive value of meat since there is currently a lack of information on this issue. Thus, the aim of the study was to determine the influence of organic and inorganic selenium on the chemical, mineral and fatty acid composition of ostrich meat.

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Materials and methods

Animals and diets

Experimental procedures were approved by the Ethical Commission (approval no. 27/2009 dated 16 April 2009). The study was conducted on 40 ostriches. Birds were kept in groups on a commercial farm in Stypułów in western Poland (*Struthiocamelus* var. *domesticus*). After hatching until 5 months of age, the birds were fed freely on a commercial ostrich starter diet (215 g/kg crude protein and 2850 kcal/kg gross energy). From the age of 5 months (40 ± 1 kg BW), the birds were randomly allocated into two groups: OSe – diet supplemented with 0.25 mg/kg of the organic form of selenium (Sel-Plex) and IOSe – diet supplemented with 0.25 mg/kg of the inorganic form of selenium (selenite, Na_2SeO_4). Components and chemical composition of diet had already been published (Poławska et al., 2012). During the experiment the body weight and feed intake of the birds was controlled monthly.

Sampling

The ostriches were slaughtered in July 2011 in an European-Union approved commercial abattoir for cattle in Wolbrom (Poland). At the age of 12 months and reaching about 95 kg of live body weight the birds went without food for 24 h, electrically stunned and slaughtered. Carcasses were maintained at room temperature (15°C) for 1 h, then chilled at 4°C for 24 h and cut up. Meat samples were taken from 16 ostriches (8 in each group) from the *M. ambiens* (AM) muscle, weighed and transported to the laboratory in insulated containers.

Chemical analysis

The chemical composition (expressed in fresh matter) of the muscle samples was determined by NIR spectroscopy (NIR Flex Solids N500 apparatus) using calibrations for feeds and ostrich meat established in other studies (Poławska et al., 2012).

Fatty acids were extracted from homogenized samples (5 g) of ostrich muscles and diets with the chloroform-methanol (2:1 v/v) procedure of Folch, Lees, and Sloane Stanley (1957). Fatty acids were extracted from homogenized samples, (5 g) of ostrich muscles using the chloroform-methanol procedure of Folch et al. (1957). After filtration through filter paper (Filtrak 390) 800 µl of filtrate were collected into vials and then evaporated under nitrogen in a heating block at 50°C. Then samples were saponified with 0.5 M KOH in methanol into the heating block (75°C). After saponification, samples were esterified with a 4% solution of SOCl2 in methanol and then the methyl esters were extracted with heptane and salted out with NaCl to separate the organic layer. After that 300 µl of esters were transferred to vials and 600 µl of heptane was added.

Fatty acid methyl esters (FAME) were analyzed using a GC-7890 Agilent gas chromatograph equipped with a 60 m Hewlett-Packard-88 capillary column (Agilent J&W GC Columns, USA) with 0.25 mm inner diameter and 0.20 µm film thickness. A 1 µl sample was injected at a split ratio of 1:40. Helium was used as a carrier gas at a flow rate 50 mL.min-1. The injector and detector were both maintained at 260°C. Column oven temperature was programmed to increase from 140°C (held for 5 min) at a rate of 4°C.min-1 to 190°C and then to 215°C at a rate 0.8°C.min-1. Individual fatty acids were identified by comparison of retention times to those of a standard FAME mixture (Supelco 37 Component FAME Mix, 47885-U – 10 mg/ml in methylene chloride, analytical standard, Sigma-Aldrich Co.) and expressed as a g/100gFAME.

The minerals contents (Na, Mg, K, Ca, Fe, Cu, Zn and Se) were determined in dry matter by inductively-coupled argon plasma mass spectrometry (ICP-MS), using *Thermo XSERIES* 2 system, after prior mineralisation in a MARS 5 microwave mineralisator/oven. The results were compared to the ICP multi-element standard solution (19 elements in dilute nitric acid, Certipur ®, 115474 Merck Millipore).

Calculations and statistical analysis

The sums of SFA (<12:0 + 13:0 + 14:0 + 15:0 + 16:0 + 18:0 + 20:0 + 21:0 + 22:0), MUFA (15:1 + 16:1 + 17:1 + 18:1) and PUFA (+ 18:2n-6 + 18:3n-3 + 20:2n-6 + 20:3n-6 + 20:4n-6 + 20:5n-3 + 22:2n-6 + 22:5n-3 + 22:6n-3) were calculated. The sum of *n-6* fatty acids was calculated as the sum of 18:2 + 20:2 + 20:3 + 20:4 fatty acids and the sum of *n*-3 fatty acids as the sum of 18:3 + 20:5 + 22:5 + 22:6 fatty acids. The ratios of PUFA/SFA and *n-6/n-3* were also calculated.

An analysis of variance using STATISTICA (vers. 9, StatSoft Inc., USA) was conducted with diet as a factor. Significant differences ($P < 0.05$) between the means were determined by Tukey's test.

Results and discussion

The average slaughter weight of ostriches was 94.3 kg and 93.6 kg respectively in the OSe and IOSe groups. The feed intake and the feed conversion ratio were 5.4 kg/kgBW and 244 g/day in both groups. The chemical composition of ostrich muscle is presented in Table 1 as related to the form of selenium. The form of selenium included in the diet of the birds (organic vs. inorganic) had no influence on dry matter, protein, fat and ash content in the *ambiens* muscle. Majewska et al. (2009) noted almost the same values for dry matter, ash and protein content, and a slightly lower intramuscular fat content (13.4 g/kg) in the *ambiens* ostrich muscle. Similar results for ostriches were obtained in the study carried out by Hoffman, Cloete, Van Schalkwyk, and Botha (2009).

The mineral composition of ostrich muscle in relation to the form of selenium is presented in Table 2. Although there were no significant differences in mineral composition including major and minor elements in muscles of ostriches fed with organic or inorganic selenium form, a tendency ($P = 0.053$) for a higher

Table 1. Chemical composition [$g{\cdot}kg^{-1}$] of *ambiens* muscle (mean ± SD) in relation to the form of selenium.

Tabla 1. Composición química [$g{\cdot}kg^{-1}$] del músculo *ambiens* (promedio ± SD) en relación a la forma de selenio.

	Diet/Group	
Item	OSe	IOSe
Dry matter	244.5 ± 5.4	244.4 ± 6.0
Protein	218.6 ± 2.5	216.9 ± 3.0
Fat	14.8 ± 3.6	16.5 ± 4.6
Ash	11.1 ± 0.13	11.1 ± 0.09

OSe – standard diet supplemented with organic form of selenium; IOSe – standard diet supplemented with inorganic form of selenium.

OSe – dieta estándar suplementada con selenio en forma orgánica; IOSe – dieta estándar suplementada con selenio en forma no orgánica.

Table 2. Mineral composition [mg/100 g] of *ambiens* muscle (mean ± SD) in relation to the form of selenium.

Tabla 2. Composición mineral [mg/100 g] del músculo *ambiens* (promedio ± SD) en relación a la forma de selenio.

	Diet/Group	
Mineral	OSe	IOSe
Major elements		
Ca	7.04 ± 0.82	7.51 ± 0.87
K	267.9 ± 20.8	287.8 ± 18.9
Mg	28.85 ± 2.18	29.74 ± 1.33
Na	43.53 ± 1.83	41.82 ± 3.90
Minor elements		
Fe	4.04 ± 0.75	3.56 ± 0.37
Cu	0.26 ± 0.04	0.27 ± 0.01
Zn	2.30 ± 0.41	2.26 ± 0.55
Se	0.040 ± 0.004†	0.031 ± 0.004

OSe – standard diet supplemented with organic form of selenium; IOSe – standard diet supplemented with inorganic form of selenium.
† – Tendency $P = 0.053$

OSe – dieta estándar suplementada con selenio en forma orgánica; IOSe – dieta estándar suplementada con selenio en forma no orgánica.
† – Tendencia $P = 0{,}053$

Table 3. Fatty acid profile [g/100gFAME] of *ambiens* muscle (mean ± SD) in relation to the form of selenium.

Tabla 3. Perfil de ácidos grasos [g/100gFAME] del músculo *ambiens* (promedio ± SD) en relación a la forma de selenio.

	Diet/Group	
Fatty acids	OSe	IOSe
C14:0	0.59 ± 0.15	0.67 ± 0.23
C16:0	18.04 ± 0.71	18.53 ± 0.70
C16:1	6.68 ± 1.20	6.20 ± 1.20
C18:0	10.35 ± 1.25	11.19 ± 1.14
C18:1n-9	26.50 ± 1.33	26.40 ± 1.35
C18:1n-7	2.53 ± 0.15	2.70 ± 0.21
C18:2n-6	16.42 ± 0.85^{a}	15.42 ± 0.96^{b}
C18:3n-3	1.70 ± 0.32	1.46 ± 0.27
C20:4n-6	8.75 ± 0.93	9.08 ± 1.03
C20:5n-3	0.40 ± 0.07^{a}	0.21 ± 0.05^{b}
C22:6n-3	0.42 ± 0.14	0.42 ± 0.21
SFA	28.98 ± 2.77	30.38 ± 1.59
MUFA	35.72 ± 2.09	35.30 ± 2.12
PUFA	27.68 ± 1.49	26.59 ± 1.89
n-6	25.17 ± 1.46	24.50 ± 1.86
n-3	2.52 ± 0.29	2.09 ± 0.36
n-6/n-3	9.99 ± 0.79^{a}	11.70 ± 0.92^{b}
PUFA/SFA	0.96 ± 0.05	0.88 ± 0.05

OSe – standard diet supplemented with organic form of selenium; IOSe – standard diet supplemented with inorganic form of selenium.
[a,b] –averages which differ in a row $P < 0.05$

OSe – dieta estándar suplementada con selenio en forma orgánica; IOSe – dieta estándar suplementada con selenio en forma no orgánica.
[a,b]–promedios que difieren en una fila $P < 0{,}05$

selenium content in the *ambiens* muscle of ostriches fed the OSe diet was observed. This confirms the Surai, Karadas, Pappas, and Sparks (2006) observation that the deposition of inorganic selenium in the body is lower than in organic forms of selenium.

The *ambiens* muscle mineral content showed differences when compared to those of Majewska et al. (2009) in particular for the major elements Na, Mg, K and Ca as well as for the minor element Cu (twice higher) and Zn (almost 50% lower). The Fe and Se content in this study was similar to those reported by Majewska et al. (2009) for the *ambiens* muscle. On the other hand, the level of the major elements Mg, Na, K, Ca in our study was similar to data obtained for ostrich meat in earlier research conducted by Sales and Hayes (1996) whereas the content of Fe was higher 3.6–4.0 mg (Table 2) vs 2.3 mg, respectively. As regard to selenium in the research carried out by Ramos, Cabrera, Del Puerto, and Saadoun (2009) for rhea meat the level of trace element was higher as compared to ostrich meat. It is interesting that among Ratite birds the highest levels of selenium were reported in emu meat (Daun & Akesson, 2004). It should be noted that Ratite meat including ostrich, rhea or emu meat, as compared to other meat of traditional species (Poławska, Cooper, et al., 2013) can be a good nutritional source of selenium that is an essential trace element implicated in a protective action against cancer (Rayman, 2005). The effect of selenium in preventing cancer consists in protecting tissues and membranes from oxidative stress and controls cell redox status (Rayman, 2005).

The fatty acids composition in relation to the form of selenium is presented in Table 3. There were no significant differences in total the content of SFA, MUFA and PUFA. However, the content of linoleic acid was significantly higher ($P < 0.05$) in the muscles of ostriches on a diet supplemented with the organic form of selenium as compared to muscles of ostriches on a diet supplemented with the inorganic form of selenium. Also the tendency ($P = 0.069$) to a higher content of linolenic acid was observed (1.7 vs 1.46 g/100gFAME).

Moreover, higher content of eicosapentaenoic acid (EPA) was confirmed in muscles from the OSe group (0.4 g/100gFAME) as compared to the IOSe group (0.21 g/100gFAME). This resulted in a lower n-6/n-3 fatty acids ratio in the OSe group (9.99) in comparison to the IOSe group (11.7).

In recent literature there is no data on the influence of the form of selenium on mineral composition and fatty acid profile of ostrich muscle. Martínez-Gómez et al. (2012) in studies on pigs also obtained a higher content of linoleic acid in *semimembranosus* muscle. However the difference was not significant. Chung, Kim, Ko, and Jang (2007) in studies on goats investigated the effect of the selenium form on the activity of antioxidant enzymes and concluded that dietary organic selenium may exert a favourable effect on antioxidant ability. The authors also observed that the organic form of selenium decreased the cholesterol level (by 15%). In chicken the positive effect of the organic form of selenium was well reviewed by Lyons et al. (2007). The authors summed up the results of latest studies and stated that organic selenium not only improves the performance and egg quality, but also the quality of meat products.

Conclusions

The results of the study indicate that dietary organic selenium supplementation improves the quality of ostrich meat as related to its health promoting properties. Providing organic selenium to the ostrich diet can alter ostrich meat composition by increasing the EPA and selenium content, what can lower the risk of cardiovascular diseases (PUFA n-3) and plays a role in human antioxidative defense (see content).

Disclosure statement

No potential conflict of interest was reported by the authors.

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